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TIME OF IRRIGATING POTATOES AS AFFECTING STOLON GROWTH AND TUBER SET AND DEVELOPMENT

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CONTENTS

INTRODUCTION

For many years the Rural New Yorker No. 2 potato has been the leading commercial variety of the Greeley, Colo., district. Although not especially a drought-resistant variety, it produces very satisfactory yields when the temperature is high if it is supplied with sufficient irrigation water. During recent years, the Triumph potato has become popular in the Greeley district as a late-crop variety. It was first tested for the late crop at the Colorado Potato Experiment Station at Greeley in 1918 with such good results that growers were encouraged to plant a portion of their acreage with this variety. At present it ranks second among the late-crop varieties grown in the district, and because of early maturity, it fits especially well into the program of the sugar-beet grower who wishes to grow potatoes. The acreage planted with Triumphs has been increasing from year to year, and it is quite possible that this variety will become the leading commercial variety in the Greeley district.

Some growers contend that the time of application of the first irrigation has a decided influence on the set of tubers. They believe that early irrigation causes an increase in set of tubers per plant, whereas withholding the initial irrigation until late in the season has the opposite effect.

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Potato varieties vary greatly in their tuber-bearing characteristics. The Rural New Yorker No. 2 variety generally sets few tubers per hill, the set being comparatively close to the stem, whereas the Triumph sets a larger number of tubers per hill and at a greater distance from the stem.

Because of conflicting ideas and lack of information on the subject, irrigation studies were conducted to determine what effect early as compared with late irrigation had on stolon growth and tuber set and development.

REVIEW OF LITERATURE

Although very extensive studies of the potato plant have been made, the development of tubers and stolon growth have received very little attention; and few, if any, investigators have studied the effect of early and late application of the initial irrigation on stolon growth and tuber development.

Kohler [1] in 1909, experimenting with the Early Ohio variety, found, upon digging tubers at 7-day intervals from July 31 to August 30, that the yield increased at a fairly uniform rate of 7.18 bushels per acre per day throughout the period.

Werner,[2] in 1917, found that tubers of the Green Mountain variety harvested August 10, 20, 30, and September 8 and 11, gave daily increases of 2.34 bushels per acre for the first 10-day period and an increase of 5.27 bushels for the last 3-day period.

In 1921, Clark [3] reported that the time of the beginning of tuber formation coincided closely with the period of flower-bud development. Studies of tubers of Rural New Yorker No. 2 at 1-week intervals showed that most tubers that grew to exceed one-half inch in diameter were formed at the beginning of the period of tuber development. The maximum rate of tuber growth occurred about 80 days after planting. Studies indicated that irrigation before tuber formation had begun increased the number of tubers.

MacDougal [4] reported in 1922 that during the period of tuber development the highest rate of enlargement in diameter was in its earliest stages when less than 1 cm in diameter. The greatest rate of increase in volume was when the tubers had reached about three-fourths of their final size.

In 1929, the writer [5] reported on experiments conducted during the years 1919–25, in which Rural New Yorker No. 2, receiving water as needed for a vigorous growth throughout the growing season, averaged 313.2 bushels per acre if watered; when plants became dark green, 290 bushels; and when the first water was withheld until growth was checked, the average was 236.4 bushels. Similar results were obtained with the Peerless (Pearl) variety during 1919, 1920, and 1921.

Jensen and Morris [6] reported in 1931 that the stolons of Russet Burbank were well started before the sprouts appeared above ground. Tubers one-eighth to one-fourth inch in diameter were formed before

[1] KOHLER, A. R. POTATO EXPERIMENTS AND STUDIES AT UNIVERSITY FARM IN 1909. Minn. Agr. Expt. Sta. Bull. 118, pp. 65–141, illus. 1910.

[2] WERNER, H. O. POTATO EXPERIMENTS 1917 AND 1918. N. Dak. Agr. Expt. Sta. Bull. 129, 32 pp., illus. 1919.

[3] CLARK, CHARLES F. DEVELOPMENT OF TUBERS IN THE POTATO. U. S. Dept. Agr. Bull. 958, 27 pp., illus. 1921.

[4] MACDOUGAL, D. T. THE COURSE OF GROWTH OF POTATO TUBERS. (Abstract) Science 55: 546.

[5] EDMUNDSON, W. C. STUDIES IN TIME AND RATE OF IRRIGATING POTATOES IN COLORADO. U. S. Dept. Agr. Tech. Bull. 118, 22 pp., illus. 1929.

[6] JENSEN, HARRY J., and MORRIS, O. M. POTATO GROWING IN THE IRRIGATED DISTRICTS OF WASHINGTON. Wash. Agr. Expt. Sta. Bull. 246, 30 pp., illus. 1931.

the plants were 4 inches high, although the tuber enlargement did not keep pace with the growth of the plants. Tubers that reached marketable size were well started by the time the plants were blooming, and the number of market-size tubers did not increase afterwards. Rapid tuber growth lasted for about 6 weeks after blooming, slowed down for about 2 weeks, and then recurred for a week, ending September 24.

OUTLINE OF THE EXPERIMENT

Studies on the effect of early and late applications of the initial irrigation on stolon growth and tuber set and development reported in this bulletin were conducted at the Colorado Potato Experiment Station at Greeley.

The soil on which the studies were made was a clay loam containing a small amount of gravel. All plots were well drained and apparently uniform. A 4-year rotation of grain, alfalfa (2 years), and potatoes was maintained throughout the experiment. Light applications of barnyard manure were made in the fall preceding the crowning of the alfalfa. The ground was left rough during the winter, and in the early spring it was plowed about 10 inches deep and a good seedbed was prepared.

Each year the plots of Rural New Yorker No. 2 and Triumph varieties were planted in triplicate. Plots consisted of seven rows, each 242 feet long and 36 inches apart, with seed pieces spaced 12 inches apart in the rows. Two rows of potatoes were planted between plots so that irrigation water from one plot would not influence development in adjacent plots. Shortly after planting, all plots received a deep cultivation and were harrowed, and subsequent cultivations were made whenever soil conditions seemed to warrant until the growth of vines interfered with cultivation.

Throughout the 7-year period that the studies were carried on, the same strain of Rural New Yorker No. 2 developed at the station was used; and the same strain of Triumph seed was purchased each fall from a grower in the northeastern part of Weld County, Colo.

Tubers weighing from 6 to 10 ounces were selected for planting and cut into blocky pieces weighing from 1½ to 2 ounces. These pieces were spread out in a thin layer on the cellar floor until the cut surfaces were suberized. The weight of the seed pieces and the method of handling the ones planted in each plot were the same throughout the experiment.

The plots of Rural New Yorker No. 2 were planted as nearly as possible on the first day of June; those of Triumph were planted as nearly as possible on June 12. Tests previously made at the station indicate that the Rural New Yorker No. 2 generally produced better yields when planted the last of May or the first of June, whereas Triumphs produced larger yields when planted on June 12 or later.

The soil was ridged by the potato planter and also by the cultivator with shovels set to add additional soil. The average depth of seed pieces below the top of the ridge was about 4.75 inches.

Throughout the experiment, the dates of irrigation were governed by soil moisture, condition of the plants, and by rainfall (table 1).

The early-irrigated plots were watered throughout the growing season whenever the plants required water to maintain a continuous vigorous growth and color of the foliage typical of the variety (table 2).

The late-irrigated plots did not receive the first irrigation (table 2) until 2 or more weeks later than the early irrigated plots, or until the plants had become dark green and were checked in their growth.

The first application of water to the various experimental plots was supplied according to the outline of the experiment, but in every case the quantity of water used was governed by the moisture content of the soil around the roots and the condition and color of the foliage at the time of irrigation. All plots were irrigated by running water on both sides of the rows, and careful examination of the soil was made during the operation. The flow of water was stopped when sufficient moisture had seeped through to moisten the soil in the row immediately under the hills. After the first irrigation, the soil was kept moist during the remainder of the season by light frequent waterings until about the first week in September when irrigation operations were terminated.

TABLE 1.—*Precipitation at the Colorado Potato Experiment Station, Greeley, Colo., April to September, 1929–35*

Period of rainfall	1929	1930	1931	1932	1933	1934	1935
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Apr. 1–10	-------	0.21	-------	-------	0.15	0.45	-------
Apr. 11–20	1.74	-------	-------	-------	.44	.40	-------
Apr. 21–30	1.30	.26	1.07	1.09	1.32	.26	1.53
May 1–10	1.40	.71	.55	.86	1.70	.50	.44
May 11–20	.12	1.45	.24	.33	1.49	.43	2.86
May 21–31	.26	.30	1.11	.52	-------	.40	2.18
June 1–10	.27	.16	.44	1.25	-------	.43	.15
June 11–20	.69	-------	.14	1.24	-------	1.63	1.22
June 21–30	-------	.15	.05	-------	-------	.50	.23
July 1–10	.20	-------	.17	.38	.19	.49	.70
July 11–20	.10	.48	-------	.05	.15	-------	-------
July 21–31	.11	.48	.17	2.06	-------	.19	.20
Aug. 1–10	1.39	1.11	.67	-------	1.13	.70	-------
Aug. 11–20	.21	3.34	.27	-------	-------	.15	-------
Aug. 21–31	-------	.45	.10	.16	1.59	-------	-------
Sept. 1–10	1.81	.15	.05	-------	.77	.17	1.48
Sept. 11–20	-------	.25	-------	-------	.17	.54	-------
Sept. 21–30	.29	.19	-------	.37	.39	-------	.52
Total	9.89	9.69	5.03	8.31	9.49	7.24	11.51

TABLE 2.—*Applications of irrigation water to the early- and late-irrigated plots of Rural New Yorker No. 2 and Triumph potatoes at Greeley, Colo., 1929–35*

Year and time of irrigation	Rural New Yorker No. 2		Triumph		Year and time of irrigation	Rural New Yorker No. 2		Triumph	
	Applications	First application	Applications	First application		Applications	First application	Applications	First application
1929:	*Number*		*Number*		1933:	*Number*		*Number*	
Early	7	June 29	7	June 29	Early	7	June 30	7	June 30
Late	4	Aug. 2	5	July 23	Late	5	July 25	5	July 26
1930:					1934:				
Early	7	July 5	7	July 5	Early	6	July 12	6	July 12
Late	6	July 21	6	July 21	Late	4	July 31	4	July 31
1931:					1935:				
Early	7	July 6	7	July 6	Early	8	July 10	8	July 10
Late	5	July 29	5	July 29	Late	6	July 26	6	July 26
1932:									
Early	10	July 5	9	July 5					
Late	8	July 19	7	July 21					

In order to study the stolon growth and tuber development, 30 hills were dug at 10-day intervals throughout the season after the first tubers had attained the weight of about 1 ounce. All hills were

taken at random and very carefully dug by hand, but none adjacent to a skip or blank hill was used.

In digging the hills, the first operation was to cut off the stems about 3 inches above the surface of the soil. The soil above and around the tubers was carefully removed by hand so the tubers would not be broken from the stolons. After the plant had been carefully dug, it was placed on a tray, washed free of all soil, and taken into the laboratory. If a tuber was broken from the plant during the digging operation, the tuber and stolon were marked, or if its exact location on the plant could not be determined, the hill was discarded. All tubers on each plant were placed in groups according to weight: (1) Under 14 g; (2) 14 to 28 g; (3) 28 to 56 g; (4) 56 to 85 g; and (5) 85 g and above. The length of stolon producing tubers 14 g and above in weight was measured, and the stolons on each plant were counted to determine the average number. The position of each tuber-bearing stolon on the stem was also recorded.

SEASONAL CONDITIONS AND IRRIGATION

The early part of the 1929 growing season was favorable for potato growing, with a fair amount of rainfall during June, July, and August; but the later part, beginning with the first week in September, was cold and rainy. On September 8 the temperature dropped to 28° F., injuring the potato vines to such an extent that there was practically no tuber growth after that date. During the growing season, the mean soil temperature was the lowest recorded for the 7-year period. The early-irrigated plots of Rural New Yorker No. 2 and Triumph potatoes received early irrigation on June 29; the late-irrigated Triumphs, July 23; and the late-irrigated plots of Rural New Yorker No. 2 received the first application of water on August 2 (table 2).

The growing season of 1930 was favorable for potato growing, the rainfall being fairly well distributed throughout the season except for June (table 1). An abundance of rain fell during August. The early-irrigated plots of Rural New Yorker No. 2 and of Triumph received their initial irrigation on July 5, and the late-irrigated plots of each variety received their first application of water 16 days later.

The year 1931 was very unfavorable for potato production because little rain fell during the growing season. The precipitation for July was 0.34 of an inch, and in September only 0.05 inch. The total precipitation from April to September, inclusive, was only 5.03 inches. The plots of Rural New Yorker No. 2 became badly infected with fusarium wilt, both *Fusarium oxysporum* Schl. and *F. eumartii* C. W. Carpenter infecting the plants. Very little fusarium wilt, however, occurred in the plots of Triumph potatoes. The early-irrigated plots of both varieties received the first application on July 6, whereas the late-irrigated plots were watered for the first time on July 29.

During the early part of the 1932 growing season there was a fair amount of rainfall. August was hot with very little precipitation, there being only 0.16 inch for the month, and only 0.37 inch during September. Fusarium wilt was especially injurious to the Rural New Yorker No. 2 variety, probably because of the high soil temperature during August. Psyllid yellows infection was also heavy in that year. The early-irrigated plots of Rural New Yorker No. 2 and Triumph received the initial application of water July 5, and the late-irrigated ones 2 weeks later.

In 1933 there was good precipitation in April and May, but no rain fell during June and only 0.34 inch was recorded for July. Owing to the lack of rainfall during June, the early-irrigated plots of Rural New Yorker No. 2 and Triumph required an additional early irrigation, the first water being applied on June 30. The late-irrigated plots of Rural New Yorker No. 2 received the first application on July 25, and the Triumph plots on the following day.

The growing season of 1934 was very unfavorable for crop production throughout the district. The winter of 1933–34 was very mild with very little snowfall. The subsoil had gradually become depleted of moisture, owing to hot dry seasons and low winter precipitation. Because of the light snowfall in the mountain area there was a shortage of water for irrigation purposes. The soil temperature was very high in 1934, as indicated by the temperature records for that year (table 3). The early-irrigated plots of Rural New Yorker No. 2 and Triumph received the first application of water July 12, and the late ones on July 31. The winter of 1934–35 was also mild with very little snowfall. There was every indication early in the season of a water shortage. In April, the precipitation recorded at the station (table 1) was 1.53 inches. Owing to the heavy rainfall and the late spring snowfall in the mountain area, the reservoirs were filled to capacity and there was an abundance of river water for irrigation. The early-irrigated plots of both varieties received the first application of irrigation water July 10, and the late-irrigated plots 16 days later.

EFFECT OF EARLY AND LATE IRRIGATION ON SOIL TEMPERATURE

The soil temperature was recorded in one early- and one late-irrigated plot to determine the effect of irrigation water upon it. Soil thermographs were used to record the temperature. The top of the bulb lying horizontally was placed in the row 3 inches below the top of the ridge. Records of the soil temperatures in the early- and late-irrigated plots were kept during July, August, and up to and including September 20, except for September 1929 (table 3).

TABLE 3.—*Mean soil temperature at a depth of 3½ inches in the early- and late-irrigated plots at intervals indicated, during the period 1929–35, at Greeley, Colo.*

Year and time of irrigation	July 1–10	July 11–20	July 21–31	Aug. 1–10	Aug. 11–20	Aug. 21–31	Sept. 1–10	Sept. 11–20
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1929:								
Early	67.0	70.9	73.4	68.2	68.4	[1] 68.3	-------	-------
Late	67.9	71.7	74.3	68.9	69.2	[1] 68.2	-------	-------
1930:								
Early	77.7	76.0	72.2	73.3	65.4	66.3	61.2	61.0
Late	78.8	76.4	75.1	75.5	65.9	66.1	61.8	61.7
1931:								
Early	77.3	80.5	81.8	73.6	71.6	66.9	65.7	67.0
Late	77.9	82.0	82.6	74.7	72.2	67.7	67.2	68.4
1932:								
Early	77.3	79.5	78.7	73.5	75.1	69.7	64.6	62.2
Late	79.3	82.3	79.7	74.6	78.3	71.9	64.2	61.5
1933:								
Early	79.6	79.0	79.8	74.0	73.5	66.5	67.9	59.6
Late	81.5	81.4	82.3	77.4	76.4	68.5	68.3	58.9
1934:								
Early	78.6	80.9	79.5	77.7	77.2	70.5	61.8	61.2
Late	78.5	82.8	82.7	79.8	78.8	71.2	62.7	61.3
1935:								
Early	79.4	76.7	76.9	75.0	71.9	69.4	61.7	64.7
Late	79.5	78.8	78.8	76.3	73.6	69.4	61.7	64.6

[1] 6-day period.

The 7-years' record of soil temperature in the early- and late-irrigated plots indicates that the temperature of the soil was lowered slightly in the early-irrigated plots by the application of water. In general the greatest difference in the soil temperature occurred during July after water had been applied to the early-irrigated plots, and before the late plots had received any. The lower temperature of the soil in the early-irrigated plot was probably due to a more rapid evaporation of moisture from the soil and the earlier shading of the ground by the plants.

The lowest soil temperature for July and August during the 7-year period was recorded in 1929. In that year, the temperature was low throughout the growing season with cold rainy weather during the first week in September and an early frost.

Very little difference occurred in the soil temperature of the early- and late-irrigated plots for September.

EFFECT OF EARLY AND LATE IRRIGATION ON STOLON GROWTH

Throughout the 7 years that the studies were conducted, the stolons on Rural New Yorker No. 2 began to form about 36 days after planting, or about July 6. Stolons arise in the axils of scaly leaves at the nodes of the underground stems. The stolons of Rural New Yorker

FIGURE 1.—Late-irrigated plot of Triumph, center; early-irrigated plots of same variety on right and left. Note differences in vine growth. Plots planted June 12. Photographed July 18. Early- and late-irrigated plots of Rural New Yorker No. 2 present a similar contrast of vine growth.

No. 2 develop slowly, the rate being governed chiefly by the amount of moisture in the soil. The plots of this variety, supplied with sufficient moisture to keep the plants growing vigorously (fig. 1), produced a fully developed stolon system by about the last of July, or in 20 to 25 days after the stolons began to form. Stolon development of

Rural New Yorker No. 2 plants that were grown in the late-irrigated plots was delayed because of insufficient soil moisture. Plants in the late-irrigated plots grew slowly from time of emergence until after the first irrigation, during which period the stolon development was also very slow.

The Rural New Yorker No. 2 plant shown in figure 2, *B*, was taken from the late-irrigated plot. The first stolon growth started about July 10. The photograph shows well the retarded growth of a plant in soil that did not contain sufficient moisture for optimum growth.

As previously stated, the Triumph plots were planted on or as near June 12 as possible. Emergence of plants in the Triumph plots was completed in 18 to 20 days with the formation of stolons beginning 5 to 6 days later. The early-irrigated plots of Triumph plants usually received the first application of water within 10 days after emerging (table 3), resulting in rapid growth and development of the plants (fig. 1). Stolons 50 to 60 mm long were frequently developed in 5

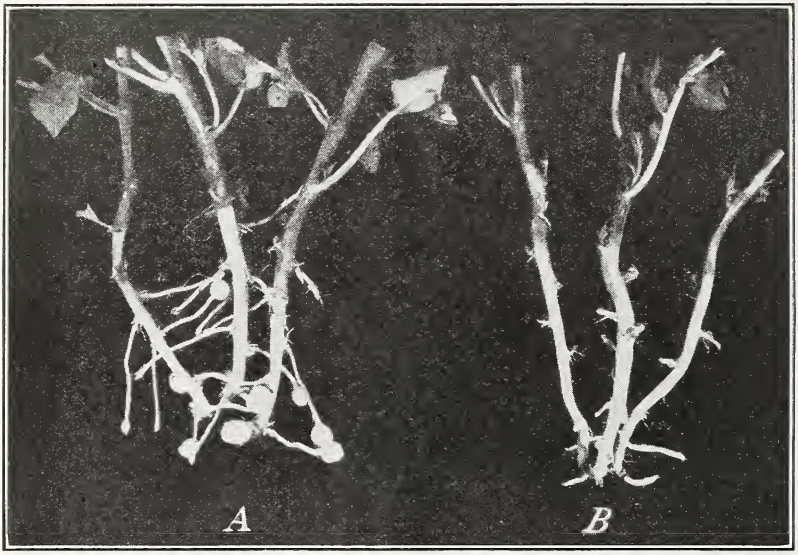

FIGURE 2.—Rural New Yorker No. 2 plants: *A*, From early-irrigated plot; *B*, from late-irrigated plot. Planted June 2. Photographed August 3.

or 6 days in the early-irrigated plots, and the entire stolon system developed in 45 days after planting (fig. 3).

Although the stolon growth of the plants in the early- and late-irrigated plots started at about the same time, the growth and development were retarded when the soil did not contain sufficient moisture to keep the plants growing vigorously, requiring from 55 to 60 days after planting to complete the stolon growth. Some Triumph stolons, growing in dry soil, become elongated, reaching the surface and developing aerial stems (fig. 4). Elongated stolons that reached the surface and produced aerial stems did not produce large tubers, but usually produced buds or tubers weighing from 5 to 10 g. Not all the stolons that developed produced tubers. These varied in length from buds to over 200 mm. Throughout the period the studies were

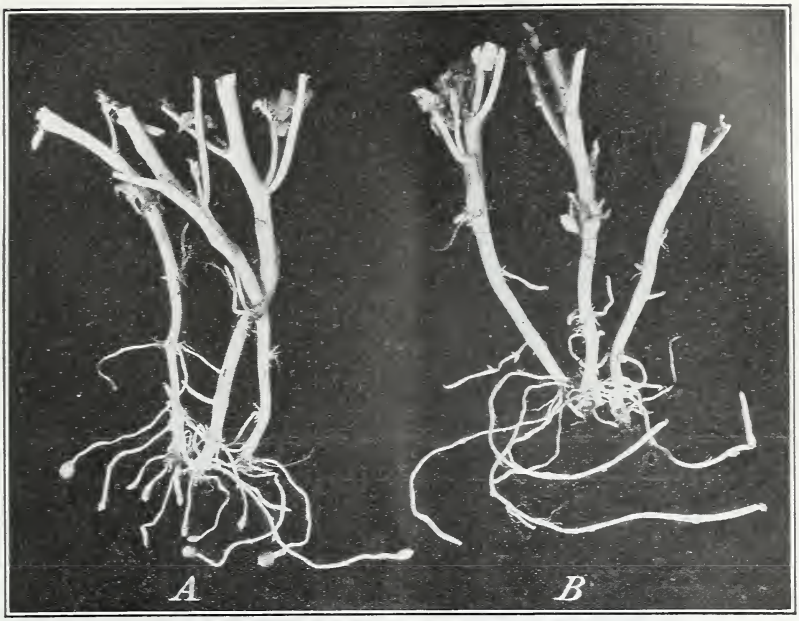

FIGURE 3.—Triumph plants: *A*, From early-irrigated plot; *B*, from late-irrigated plot. Planted June 12. Photographed July 27.

FIGURE 4.—Triumph plant from late-irrigated plot showing excess stolon growth that occurs frequently in a hot, dry season when the soil contains insufficient moisture for a normal set of tubers. Photographed August 20, 1934.

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conducted, no excess stolon growth was developed by Rural New Yorker No. 2, even under the most adverse growing conditions. The shortest stolons of the Rural New Yorker No. 2 were developed in 1929, when the tuber-bearing ones in the early-irrigated plots averaged 9 mm in length (table 4). The longest tuber-bearing stolons of this variety were produced in 1933 when the plants in the late-irrigated plots produced tuber-bearing stolons averaging 51.5 mm in length.

TABLE 4.—*Average length of stolons producing tubers 14 g and above, and the average number of stolons and stems per plant of Rural New Yorker No. 2 and Triumph, at Greeley, Colo., 1929–35*

RURAL NEW YORKER NO. 2

Year	Stems		Stolons		Tuber-bearing stolons	
	Early irrigation	Late irrigation	Early irrigation	Late irrigation	Early irrigation	Late irrigation
	Number	*Number*	*Number*	*Number*	*Mm*	*Mm*
1929	2.31	2.12	27.6	27.0	9	18
1930	3.22	3.15	26.0	29.5	46	41
1931	2.53	2.23	27.5	23.0	13	18
1932	3.14	3.09	23.0	18.6	17	15
1933	2.43	2.32	26.0	27.5	36	51
1934	2.52	2.67	27.6	32.0	24	23
1935	3.13	2.78	35.5	31.7	25	27
Average	2.75	2.62	27.6	27.1	24	28

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1929	3.16	3.19	40.5	40.1	57	75
1930	4.34	4.12	42.7	46.0	98	92
1931	4.08	3.92	43.5	42.3	111	96
1932	3.71	4.08	45.5	43.0	92	108
1933	2.82	2.82	33.3	42.5	102	104
1934	3.05	3.20	40.0	33.5	117	91
1935	3.34	3.13	38.5	38.8	76	66
Average	3.50	3.49	40.6	41.0	93	90

The Triumph also produced the shortest stolons in 1929. In that year the plants growing in the early-irrigated plots produced tuber-bearing stolons that averaged 57.5 mm in length, and the average length of such stolons in the late-irrigated plots was 75.25 mm. The longest Triumph tuber-bearing stolons were produced in 1934 by plants grown on the early irrigated plots, the average length being 117 mm. In that year, the late-irrigated plots produced tuber-bearing stolons 91.25 mm in length; however, it was noted that the longest Triumph stolons frequently did not produce tubers. This was especially true in 1934 when many stolons emerged from the soil and formed aerial stems. This condition is believed to be responsible for the apparently shorter stolons produced by the plants in the late-irrigated plots in 1934.

The time of application of irrigation water had a decided effect on stolon growth and development, but did not affect the number of stolons. The shortest tuber bearing stolons of both varieties were produced by plants in the early irrigated plots in 1929, the year of the lowest soil temperature. The results would indicate that moisture

and soil temperature have some effect on the length of tuber-bearing stolons and those which develop no tubers.

EFFECT OF EARLY AND LATE IRRIGATION ON TUBER SET AND DEVELOPMENT

Throughout the 7 years that these studies were conducted, there was sufficient moisture in the soil to sprout the seed; therefore, it was not necessary to "irrigate up" to obtain a uniform sprouting. The early irrigated plots were watered when the plants required irrigation to maintain a continuous vigorous growth throughout the season and to maintain the color of the foliage typical of the variety (table 2).

Plants grown in the early irrigated plots developed much more rapidly than those grown in the late-irrigated plots (figs. 5 and 6).

FIGURE 5.—Two hills of Triumph potatoes: *A*, From early irrigated plot; *B*, that from late-irrigated plot. Planted June 12. Photographed August 15.

Early irrigation not only had a decided influence on vine growth and stolon development but also on the time of tuber formation and rate of development, the first indication of tuber formation being the enlargement of the terminal bud of the stolons (fig. 3). Lateral buds on the stolons developed into small tubers giving the appearance of a large set of tubers per plant, 30 to 40 small tubers frequently being formed with the initial set. A comparatively small number of these, however, continued to grow and develop into large tubers (fig. 7).

The small undeveloped tubers remained about the same size until late in the growing season, when they shrivelled and decayed. However, if the lower portion of the stems of the plants became diseased or injured to the extent of cutting off the supply of plant food from the tubers at the injured portion of the stem, the small undeveloped tubers attached to stolons about that portion frequently developed

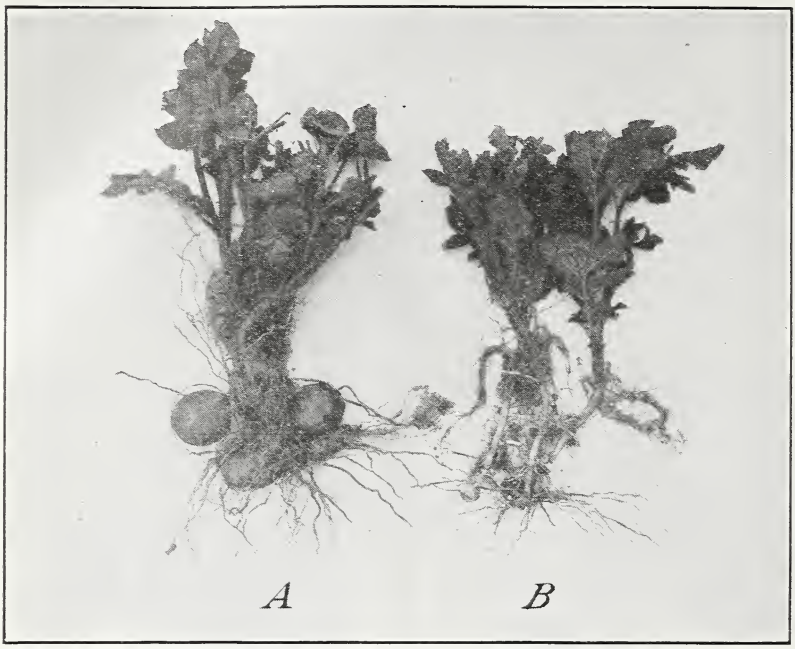

FIGURE 6.—Two hills of Rural New Yorker No. 2: *A*, From early irrigated plot; *B*, that from late-irrigated plot. Planted June 2. Photographed August 29.

FIGURE 7.—Hill of Triumph potatoes showing both large and small tubers. The small, undeveloped tubers generally shrivel and decay at the end of the growing season.

into large tubers (fig. 8). Later development of tubers above the injured portion of the stem gave the appearance of a second set of tubers.

While these studies were being conducted, Rural New Yorker No. 2 was planted at a depth of 120 mm and Triumph at a depth of 127 mm. The Rural New Yorker No. 2 planted at this depth usually developed eight nodes on that portion of the stem growing beneath the surface of the ground, and the Triumph planted at 127 mm usually developed six nodes. Table 5 gives the length of the internodes of the underground stems of both varieties.

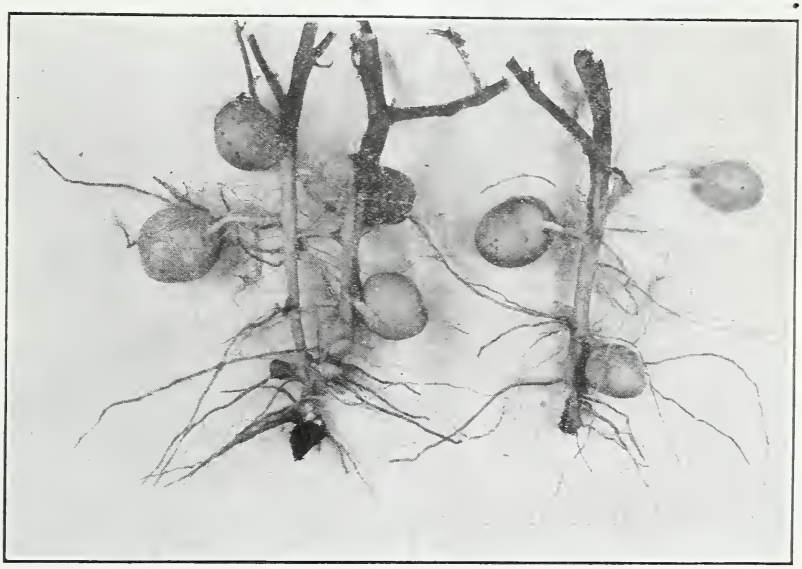

FIGURE 8.—Lower portion of potato stem infected with fusarium wilt, checking stolon growth and tuber development at the lower nodes, resulting in tuber development at the upper nodes.

TABLE 5.—*Average length of internode of the underground stems of Rural New Yorker No. 2 and Triumph potatoes during the period 1929–35, at Greeley, Colo.*

Internode	Length of internodes		Internode	Length of internodes	
	Triumph	Rural New Yorker No. 2		Triumph	Rural New Yorker No. 2
	Millimeters	*Millimeters*		*Millimeters*	*Millimeters*
First[1]	15.8	14.7	Fifth	25.6	20.2
Second	25.1	19.2	Sixth	21.2	18.8
Third	32.2	18.9	Seventh	----------	16.4
Fourth	30.9	20.1	Eighth	----------	16.2

[1] Lowest internode.

For the 7-year period, 16 percent of Rural New Yorker No. 2 tubers produced in the early-irrigated plots developed at the first node, and 24 percent at the second node (table 6). In the late-irrigated plots, 14 percent of the tubers were produced at the first node and 22 percent at the second node. In 1932, owing to a heavy infection of fusarium wilt, only 5 percent of the tubers in the early-irrigated plots were produced at the first node, and only 3 percent in the late-irrigated plots were developed at the second node (fig. 8).

TABLE 6.—*Percentage of tubers produced at the different nodes from the early- and late-irrigated plots of Triumph and Rural New Yorker No. 2, during the period 1929–35, at Greeley, Colo.*

Node	Triumph		Rural New Yorker No. 2		Node	Triumph		Rural New Yorker No. 2	
	Early irrigation	Late irrigation	Early irrigation	Late irrigation		Early irrigation	Late irrigation	Early irrigation	Late irrigation
	Percent	*Percent*	*Percent*	*Percent*		*Percent*	*Percent*	*Percent*	*Percent*
First [1]	33.0	30.0	16.0	14.0	Fifth	4.4	5.3	10.4	11.3
Second	29.8	26.7	24.4	22.0	Sixth	1.0	1.4	7.0	6.8
Third	21.8	23.3	22.2	24.4	Seventh	.0	.0	3.0	2.4
Fourth	10.0	13.3	16.0	17.7	Eighth	.0	.0	1.0	1.4

[1] Base of stem.

A larger percentage of Triumph tubers were produced at the base of the stem than in Rural New Yorker No. 2. A comparison of percentage of tubers produced at the different nodes is given in table 6.

Triumph plants grown in the early-irrigated plots began to form tubers about 45 days after planting and produced some tubers weighing 28 g in 55 to 60 days, or by August 6 to 10. The plants grown in the late-irrigated plots, the growth of which was retarded because of insufficient moisture for optimum growing conditions, generally began to set tubers about 10 days later than those in the early-irrigated plots.

Rural New Yorker No. 2 plants, grown in the early-irrigated plots, began to form tubers about 60 days after planting, and generally produced some tubers weighing 28 g in 75 to 80 days, or by August 16 to 20. The plants grown in the late-irrigated plots generally began to set tubers about 10 days later, there being some variation due to rainfall and other seasonal conditions.

In order to make a comparative study of number and size of tubers produced in the early-irrigated with those in the late-irrigated plots, 30 hills were dug from each at 10-day intervals. The first period for studying the Triumph tubers was August 6 to 10, and for Rural New Yorker No. 2, August 16 to 20. Table 7 gives a comparison of the average number of Triumph tubers of certain sizes produced per hill in the early- and late-irrigated plots at intervals, for the years 1930–35. For the 6-year period, the early-irrigated plants were the first to develop tubers. By September 6 to 10, the last period in which the Triumph tubers were studied, the plants in the early-irrigated plots had developed 6.97 tubers weighing 14 g or more per hill, of which 4.27 tubers weighed 85 g or more. The plants in the late-irrigated plots, by the same dates, had produced a slightly larger average number of tubers per hill weighing 14 g or more, but a smaller number per hill weighing 85 g or more.

TABLE 7.—*Average number of Rural New Yorker No. 2 and Triumph tubers per hill from early- and late-irrigated plots at intervals indicated, at Greeley, Colo.*

Date	Tubers of indicated weight grown under early irrigation [1]					Tubers of indicated weight grown under late irrigation [2]				
	14 to 28 g	28 to 56 g	56 to 85 g	85 g and above	14 g and above	14 to 28 g	28 to 56 g	56 to 85 g	85 g and above	14 g and above
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
RURAL NEW YORKER No. 2 (1931–35)										
Aug. 16–20	1.76	0.86	0.13	0.09	2.84					
Aug. 26–30	1.17	2.19	.61	.67	4.64	1.37	1.41	0.27	0.07	3.12
Sept. 6–10	.81	1.75	1.01	2.15	5.72	.94	1.75	1.04	1.48	5.21
Sept. 16–20	.55	1.21	.76	3.42	5.94	.44	1.40	.77	2.76	5.37
TRIUMPH (1931–35)										
Aug. 6–10	1.53	1.49	0.27	0.17	3.46					
Aug. 16–20	1.32	1.93	1.15	1.43	5.83	2.37	2.10	0.44	0.25	5.16
Aug. 26–30	.88	1.77	1.22	2.99	6.86	1.60	2.45	1.32	1.87	7.24
Sept. 6–10	.65	1.10	.95	4.27	6.97	.97	1.96	1.31	3.58	7.82

[1] Average number of stems per hill in the early-irrigated plots of Rural New Yorker No. 2 was 2.75 and Triumph, 3.59.

[2] Average number of stems per hill in the late-irrigated plots of Rural New Yorker No. 2 was 2.60 and Triumph, 3.57.

Table 7 also gives a comparison of the average number of Rural New Yorker No. 2 tubers produced per hill in the early- and late-irrigated plots at 10-day intervals for the years 1931–35. For the 5-year period, the early-irrigated plots produced 0.09 tuber per hill weighing 85 g or more by August 16 to 20, and an average of 2.84 tubers weighing over 14 g. No tubers were produced in the late-irrigated plots by that date. By September 16 to 20 the plants in the early-irrigated plots had developed 5.94 tubers weighing 14 g or more. By this same period the late-irrigated plots had produced 5.37 tubers per hill weighing 14 g, but only 2.76 tubers weighed 85 g.

The growing season of 1934 was hot and dry, preceded by a mild winter with very little snowfall, resulting in a scarcity of water for irrigating. The soil temperature was high during July and August (table 3). The first water was applied to the early-irrigated plots of Triumph and Rural New Yorker No. 2 on July 12, and the first application to the late-irrigated plots of both varieties was made July 31. With each irrigation, sufficient water was supplied to the plants to enable them to maintain a continuous vine growth, but there was not enough moisture in the soil for an early tuber set, and development was greatly retarded in all plots. The early-irrigated plots of Triumph that normally had produced some tubers weighing 28 g in 55 to 60 days after planting, developed no tubers of that weight by the end of the 60-day period, and only 0.10 tuber per hill weighing 28 g within 70 days after planting. Tuber formation was also delayed in the late-irrigated plots of Triumph, there being but 0.07 tuber weighing 28 g per hill in the late-irrigated plots within 75 to 80 days after planting.

In all years except 1934, Rural New Yorker No. 2 plants in the early-irrigated plots produced tubers weighing 28 g in 75 to 80 days after planting; the late-irrigated plots produced tubers of approximately the same weight about 10 days later. In 1934, no tubers weighing 28 g were produced in the early-irrigated plots by August

20, and only 0.03 tuber per hill was developed by August 30. No tubers weighing 28 g were produced in the late-irrigated plots by August 30, and only an average of 0.77 tuber per hill by September 10.

Although high soil temperatures prevailed during July and August of 1934, the retarded tuber set and development was due largely to lack of soil moisture as evidenced by plots of Triumph and Rural New Yorker No. 2 planted on another tract of land. On the upper end of this particular potato field, difficulty was experienced in supplying the plants with sufficient moisture to enable them to make a vigorous growth. The lower end of it was comparatively flat with only fair drainage. Both Rural New Yorker No. 2 and Triumph varieties grown on this low flat land, which contained a good supply of moisture, produced an early set of tubers, whereas the same varieties grown at the upper end of the field in soil with a low moisture content did not set tubers until 10 to 12 days later.

For the years 1932–35, the total weight of tubers per hill was recorded at the time notes were taken on the number of tubers per hill. These are shown in table 8.

TABLE 8.—*Average weight per hill of Rural New Yorker No. 2 and Triumph tubers from early- and late-irrigated plots, 1932–35, at Greeley, Colo.*

Weight recorded	Rural New Yorker No. 2		Weight recorded	Triumph	
	Early irrigation	Late irrigation		Early irrigation	Late irrigation
	Grams	*Grams*		*Grams*	*Grams*
Aug. 16–20	104.0		Aug. 6–10	148.0	
Aug. 26–30	220.3	104.3	Aug. 16–20	344.0	257.0
Sept. 6–10	440.0	355.0	Aug. 26–30	603.5	476.0
Sept. 16–20	658.0	537.5	Sept. 6–10	794.8	694.3
Sept. 26–30	815.5	653.0			

Early irrigation produced the largest yield of prime tubers at time of harvest throughout the time the studies were conducted even though the harvest was delayed because of a late frost.

SUMMARY

The early-irrigated plots were watered throughout the growing season when the plants required it to maintain a continuous vigorous growth and the color of the foliage typical of the variety. The late-irrigated plots did not receive the first irrigation until 2 or 3 weeks later, or until the plants assumed a dark-green color and were checked in their growth.

Early irrigation caused a slight lowering of the soil temperatures during July and August. The soil temperatures were very similar during September in both the early- and late-irrigated plots.

Early applications of irrigation water on Rural New Yorker No. 2 and Triumph plants had little or no effect on the number of stolons produced per hill, the number remaining rather constant for the variety; however, such irrigation caused a much more rapid growth and development of stolons. The shortest stolons of both varieties were produced in the early-irrigated plots in the year in which the soil temperature was the lowest. The results would indicate that moisture

and soil temperature have some effect on the length of tuber-bearing stolons and on those which do not develop tubers. In years of high soil temperature, some Triumph plants in the late-irrigated plots developed long stolons with aerial stems with no tubers, the tubers developing on shorter stolons. Rural New Yorker No. 2 did not produce any excess stolon growth even under adverse growing conditions.

Rural New Yorker No. 2 and Triumph plants that received early irrigation water produced an early set and a more rapid development of tubers than did the plants of the same variety that received the initital irrigation later in the season.

Early irrigation had little effect on the total number of tubers produced per hill of either Rural New Yorker No. 2 or Triumph, but produced a larger number of tubers weighing 85 g or more.

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